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TECHNOLOGY FORESIGHT OF UK SMES: OPPORTUNITIES AND CHALLENGES FOR GROWTH AND PRODUCTIVITY

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Abstract

Since the early 2000s, a significant number of corporate organisations have applied an innovative management approach for the monitoring of new technologies and the systematic analysis of their future evolution and impact. Despite the growing popularity of technology foresight amongst large corporations, there is little evidence of its use in SMEs. However, foresight might be very beneficial to SMEs facing technological changes, by enabling them to pool their knowledge about new technologies and thus to set priorities and generate joint efforts, in a systematic way, for the optimal allocation of their resources. This paper aims to develop and test a simple, effective and scalable foresight method, specifically responding to the needs (and challenges) of SMEs in UK clusters. We illustrate the results of a foresight exercise that involved 16 SMEs in a London Digital Health cluster. The main novelty of this foresight exercise is related to the involvement of different entrepreneurs of different SMEs (rather than a team of managers from the same organisation, as it is usually the case of technology foresight in large corporations) and the adoption of a bespoke set of different techniques, tailored to the specific needs of SMEs.

1. Introduction

Technological change is a key challenge for any organization, especially for SMEs that have limited resources for monitoring, developing and transferring existing technologies from other business sectors (Nguyen et al., 2015). Yet, technological change provides huge entrepreneurial opportunities for firms, including boosting the productivity of SMEs (BEIS, 2018) and sustainability (Wiener et al., 2020). Organisations that are able to identify early new technologies and anticipate their future evolution can achieve significant "first mover advantages". Technology 'foresight' is a modern management practice that can be very effective at fostering the adoption and diffusion of new technologies among SMEs and thus contribute boosting their productivity (Roveda and Vecchiato, 2008). This paper aims to analyse a simple, effective, and scalable 'foresight' method designed to enable SMEs to (i) identify promptly relevant technologies, (ii) assess their potential risks and opportunities and (iii) set out priorities for their adoption in a rational way.

The main novelty of this paper is its analysis of a project that has designed a bespoke set of foresight techniques, tailored to the specific needs of SMEs. This approach differs from usual foresight activities in large corporations that involve a team of managers belonging to the same organisation. On the one hand, the foresight project has predicted a list of critical technologies and actions that SMEs can implement in order to ultimately improve their productivity. On the other hand, the outcomes of the foresight project appears to have developed networks that foster the cooperation and integration of SMEs, by developing links with external partners including universities, technology providers, and funding institutions.

This paper is structured as follows. First, we discuss the recent literature on foresight, technological change, and SME management. Then we describe the methodology and foresight project under scrutiny and in section 4 we illustrate the main outputs of the project, i.e., the foresight methodology, the list of critical technologies, and the list of key actions for their transfer to SMEs. Finally, we discuss the lessons learnt and propose avenues for future research.

2. Technological change, foresight, and SME management

2.1 Technological change and uncertainty

Technological change is a key challenge for organisations, particularly for SMEs that have limited resources for monitoring and developing emerging and disruptive technologies; or for adopting technologies that already exist in other industries/sectors (BEIS, 2018; Vecchiato and Roveda, 2014). In the remainder of this paper, we use the term "new technologies" to refer to both emerging technologies and existing technologies that might be transferred from other industries/sectors. Specifically, it has been recognised for decades that SMEs face barriers in the adoption of new technology because they create different layers of uncertainty which hampers investment and the commitment of resources (Milliken, 1987).

The first kind of uncertainty regards the evolution of a new technology (i.e., '*state*' uncertainty): managers experience such kind of uncertainty when they do not feel able to understand the future pattern of evolution of this technology. A second kind relates to managers' inability to predict the impact of a new technology on the organization (i.e., '*effect*' uncertainty), with regard for instance to the development of new product or service features (or radically new product or services) or to the improvement of current features. Finally, a third kind of uncertainty relates to the difficulty of understanding what response options are available to the organisation and what is the value or utility of each option is (i.e., '*response'* uncertainty). Coping with the uncertainty surrounding new technologies is generally difficult for large corporations but it is definitely more challenging in the case of SMEs because of their limited access to data and knowledge (both tacit and explicit) about the state, effect and response to new technologies (Roveda and Vecchiato, 2008).

Technological change, however, presents a huge opportunity for those organisations that are able to identify new technologies early and anticipate their future evolution, impact and response options (Peltier and Zhao, 2012; Nguyen, 2015; Solomon and Linton, 2016). In this regard, mainstream scholars define as “first mover advantages” the main benefits that a firm might gain by anticipating – and thus by pioneering – technological changes and, conversely, the disadvantages encountered by late mover firms that fail to anticipate such changes (Suarez and Lanzolla, 2007; Vecchiato, 2015). The main sources of first mover advantages lie in three basic categories: superior technological capabilities, customers’ switching costs, and pre-emption of scarce inputs or assets.

Technological capabilities result from the ‘learning’ curve, where costs fall with cumulative output, or more simply from superior knowledge, where competitive edges in product or process features are a function of innovation expenditures. Customers’ switching costs relate to the extra resources which late movers must invest in order to attract customers away from the first mover firms; switching costs can stem from initial transaction costs or investments that customers make in adapting to the first movers’ products. Finally, the pre-emption of scarce assets might regard physical resources, process inputs or geographic space or customers’ perceptual space. First mover advantages tend to be observed mainly in the form of higher profits and market share: the longer the time a firm anticipate new technologies before its rivals, the higher the likelihood of achieving such benefits.

2.2 Foresight and uncertainty management

Since the early 2000s, a significant number of corporate organisations successfully applied an innovative management approach to the monitoring of new technologies and the systematic analysis of their future evolution and impact (Vecchiato, 2012; Georghiou et al., 2008). Such approach is often named under the umbrella of “technology (or strategic) foresight” (Miles, 2010). This includes techniques like technology roadmapping and Delphi. Roadmapping consists of representations as interconnected nodes of major changes and events in the external environment, such as new technologies, products, and markets. Delphi involves a number of experts answering a questionnaire in two or more rounds. After each round, the experts are given a summary of average forecasts and the reasons for such forecasts, and are encouraged to revise their early answers in the light of this feedback.

Despite the growing popularity of technology foresight amongst large corporations, there is little evidence of its application or adoption in SMEs. However, foresight might be very beneficial to SMEs in an environment where there are technological changes. The approach may for example, enable them to pool their knowledge about new technologies and thus to set priorities and joint efforts, in a systematic way, for the optimal allocation of their resources (Roveda and Vecchiato, 2008). This may be particularly relevant for SMEs that operate in clusters. A cluster in this case is defined as a geographically proximate group of interconnected companies and interrelated institutions in a particular industry or business area. On the one hand, clusters are a relevant driver of the competitiveness and innovation capability of a region or country (Porter, 1990). On the other hand, technology innovation in industrial clusters is extremely complex as it involves a wide set of autonomous players, on both a vertical (providers of complementary products, services, components and machines) and a horizontal dimension (small and medium firms providing the same kind of products and/or services). In order to be successfully adopted, a new technology requires different and autonomous players to coordinate their efforts into the implementation of the new technology (Roveda and Vecchiato, 2008). In some sense, this resonates with the concept of an entrepreneurial ecosystem and the actors within such a system (Laveren et al., 2020) but the technology foresight approach in this paper addresses a systematic and organised method of technology adoption.

The micro-economic fabric of a cluster of SMEs, namely its fragmentation across a mass of firms, is thus an essential condition for the continuous enrichment and evolution of the knowledge underlying the technologies applied within the cluster. At the same time, this fabric turns out to be the greatest obstacle to the adoption of new technologies. The shared culture and behavioural patterns that work well in relation to incremental technology evolution, may be insufficient to embrace the paradigmatic shifts associated with new and disruptive technologies. This requires a critical mass of SMEs to become aware of the benefits that these technologies may bring in terms of cost savings, increased productivity, or product differentiation and this critical mass leads the transition of other SMEs within the cluster.

Technology foresight has already been proved to be a modern, effective management approach amongst corporate organisations that brings concrete benefits to the participants, especially: communication; consensus; co-ordination; concentration on the longer term; and commitment (Martin, 1995). These outcomes are commonly labelled as the “5Cs” of foresight and might have a key role in fostering technological change in SME clusters, by fostering the creation of networks among the SMEs participating in this foresight project and ultimately by enhancing their cooperation and integration for the development/adoption of new technologies. However, there is an absence of research on the use of technology foresight in SMEs. This paper seeks to fill a gap in extant literature on SME and innovation, and draws upon evidence from a project that sought to develop and test a new foresight method aimed at coping with the challenges inherent in the micro-economic fabric of a cluster of SMEs.

3. Methodology

3.1. Sampling

The fieldwork was conducted with a group of 16 Digital Health SMEs based in London. The sector and cluster of SMEs was selected according to its impact on the UK economy, its impact on NHS services, and the potential/need for enhancing its current level of productivity (NESTA, 2017; ONS, 2017). The novelty of the foresight project is related to the involvement of different entrepreneurs from different SMEs and the adoption of a bespoke set of different techniques, tailored to the specific needs of SMEs.

The SMEs of the selected Digital Health cluster have the advantage of the ability to process a wider range of information about new technologies than working independently. By allowing these SMEs to have an active role in the identification of the new technologies that are critical to them, the project was found to increase the likelihood that these firms adopt these new technologies – and conversely reduce the risks that new technologies are rejected or that public money is not effectively used. Ultimately, entrepreneurs had the opportunity of working together and coordinating their efforts amongst themselves and with UK policy makers and funding institutions.

3.2. Foresight method

Technology foresight is an approach that has been used mainly by corporate organisations as a management approach to monitor new technologies and the systematic analysis of their future evolution and impact (eg Miles, 2010). The foresight method in this project consisted of three different main phases. The *first phase* focused on the identification of the SMEs to involve in the project (target number: 15), the identification of the technology experts to involve in the project (target number: 5), the raising of awareness among the entrepreneurs and experts, the gathering of background information, and the identification of a preliminary list of technologies that are potentially relevant for future SMEs' productivity. The identification of the relevant technologies was based on techniques including a) an analysis of patenting activity by leading organisations (e.g., corporate firms and research centres) operating in the Digital Health sector, at an international level; b) a bibliometric analysis of publications; c) an analysis of project proposals funded by public bodies (e.g. the Horizon 2020 of the EU); and d) a survey involving all the SMEs entrepreneurs and technology experts.

The *second phase* of the project consisted of a 3-round Delphi process enabling the evaluation of the preliminary list of technologies selected in the previous pase; and the identification of the most relevant technologies for the target cluster of SMEs. The evaluation is based on two dimensions: the attractiveness and the feasibility of 16 listed relevant technologies in the digital health sector. The Delphi process involved all the technology experts and SMEs entrepreneurs. This enabled the participants to compare their previous scores with the average score and comment on different types of technology, and to decide whether to keep or change their scores in the second and third round of the Delphi process.

The *third phase* consisted of two of workshops. Here all the entrepreneurs and technology experts met and assessed the evolution, impact (e.g. new products and process), and response options available for adopting/developing the critical technologies identified in the previous phase. The workshops also explored the joint actions enabling the SMEs to overcome the limitations - e.g., expertise, financial – of each individual firm.

3.3. Key activities

Phase 1

The first phase of the project was conducted between November 2018 and January 2019.

A preliminary search of innovative digital health SMEs based in the London area pointed out that many of these companies were linked to the Digital Health London Accelerator (DHLA). We approached the managers of the DHLA and subsequently established a strong and effective collaboration. Together, we identified 16 companies to take part in the project. The manager of each company was interviewed by a member of our project team. During the interviews we explained the methodology to be applied in the next Delphi process. After the interviews, two managers withdrew, due to other commitments or because they didn't feel comfortable with the technology evaluation process. Altogether, 14 companies took part in the Delphi.

Contextually, we identified six technology experts: three belonged to DHLA and three from the Computer Science Department of a University. The experts were identified on the basis of their skills and current activities in the digital health sector. Based on both Google Scholar and IEEE Explore search engines, we selected almost 600 scientific publications covering the adoption of ICTs in the healthcare domain. Analysing these papers (mainly published between 2013 and 2018), we are able to undertake an up-to-date review of the scientific literature. This helped the identification of the main ICTs-based healthcare paradigms developed in the last few years, as well as the ICTs paradigms and the ICTs technology pillars that underpin them. At the same time, we carried out desk research (internet sources, business and media press) covering recent foresight exercises in the healthcare sector, at an international level, and future oriented publications depicting futures scenarios for digital health applications and technologies. Our desk research also covered the white papers regarding the evolution of healthcare of several national governments in the EU, USA and Asia. This also included the UK Government's White Paper on "The future of healthcare: our vision for digital, data and technology in health and care (published on October 17th 2018). Finally, we monitored recent trends in related sectors including Home Automation, Digital Media, Digital Game and Self-Driving Cars, searching for new technologies that might be transferred to the Digital Health sector.

The results of this research was a preliminary list of 26 technologies that might affect the future evolution of the digital health sector and have an impact upon the future growth (or even the survival) of digital health SMEs. We classified these 26 technologies into four main categories: communication; hardware; software; transversal technologies (technologies that involve 2 or more of the above domains or might be transferred from other industries). These 26 technologies are:

1. Machine to machine communication
2. Internet of things
3. Cloud computing
4. Fog computing and Mobile Edge computing
5. Wireless body area networks communication protocols
6. Wireless body area networks
7. Wireless sensors (wearables)
8. Smart devices
9. Robotics
10. Smart e-health systems
11. 3D printing
12. Health Data Formats
13. Big data analytics
14. Artificial Intelligence
15. Image analysis and facial recognition
16. Speech recognition and chatbots
17. Social media
18. Security and privacy (cryptography)
19. Augmented reality and virtual reality
20. Biometrics
21. Blockchain
22. Micropayments
23. Technologies from self-driving cars
24. Automated Transport Systems (drones, autonomous ambulance)

25. New touch interfaces and displays
26. Human augmentation

Phase 2

The second phase of the project included a three-round Delphi process for the evaluation of the list of digital health technologies identified in the previous phase. This took place between mid-January 2019 and mid-April 2019. The third phase involved organising a workshop to deliver the findings of the projects; hold interactive discussions between SME owner-managers, experts and researchers to analyse the impact and evolution trends of the key technologies; and generate the list of actions to enable SMEs to adopt new technologies.

Hereafter in this section we describe the methodology developed and applied in the evaluation process. The evaluation specifically focused on the digital health SMEs based in the London area, especially the SMEs of the Digital Health London Accelerator. The following subsection presents the instructions that were shared with the SMEs owner-managers.

Attractiveness evaluation. The attractiveness of a given technology refers to its capability to improve products (or services) and product features and thereby foster the competitiveness (and ultimately the sales and profits) of digital health companies. You are given 8 points: please distribute these 8 points among the 26 technologies (e.g., 1 point each allocated to 8 technologies, or 2 points each allocated to 4 technologies, or 3 points each to 2 technologies and 1 point each to two other technologies, etc. You might even give all the 8 points to just one technology). Please repeat this process for each one of the following four criteria and, after that, provide an overall evaluation for the attractiveness of the technologies.

Attractiveness criteria	1a) *Economic impacts*: these regard the size (number of customers, potential sales) and dynamics (rate of growth) of the markets for the technology in the UK. The economic impacts

	regard as well the opportunity for exporting new services/products based on the technology into foreign markets, e.g., EU or the Commonwealth. The attractiveness of a technology increases when the economic impacts are high - so the higher you think the economic impacts of a given technology are, the more points you might allocate to this technology.
	1b) *Competition*: Intensity of competition from foreign companies (other EU countries, US, Asia) that are developing as well the technology and new products/services that are based on the technology. The attractiveness of a technology decreases when the intensity of competition is high.- so the lower you think the competition for a given technology is, the more points you might allocate to this technology.
	1c) *Uncertainty*: Uncertainty regarding the future development of the technology (i.e., capability of the technology to eventually provide the expected benefits). The attractiveness of a technology decreases when the uncertainty is high, so the lower you think the uncertainty about a given technology is, the more points you might allocate to this technology.
	1d) Please evaluate the OVERALL attractiveness of the technologies – the more attractive you think a technology is, the more points you might allocate to this technology.

Feasibility evaluation. Feasibility links a given technology with the concrete capability of digital Health SMEs to develop or adopt this technology.

Please select the four technologies that you consider to be the most feasible. These four technologies might NOT be those that you have considered to be the most attractive. Please repeat this process for each one of the following three criteria and, after that, provide an overall evaluation for the feasibility of the technologies.

Feasibility criteria	*2a) Capabilities:* Technology capabilities (assets and knowledge available in the UK industrial and scientific system, companies – both large and SMEs – representing potential partners, suppliers, universities, public research centres), especially in the London area, for developing the technology. The feasibility of a technology increases when technology capabilities are high - so the higher you think the capabilities available for a given technology are, the more points you might allocate to this technology.
	2b) Congruence: Congruence of the technology to the UK socio-economic system, in relation to the local demand (e.g., NHS, demographics of population), complementary technologies in related sector (e.g., game industry or automotive industry, local (regional and national) regulation. The feasibility of a technology increases when the congruence is high - so the higher you think the congruence of given technology is, the more points you might allocate to this technology.
	2c) Technological investments, i.e., the average amount of financial resources necessary for a company to gain the competences and assets needed to adopt the technology and provide competitive products/services based on the technology itself. The feasibility of a technology decreases when the technology investments are high - so the lower you think the investments necessary for a given technology are, the more points you might allocate to this technology.
	2d) Please evaluate the OVERALL feasibility of the technologies - the more feasible you think a technology is, the more points you might allocate to this technology.

At the end of the first Delphi round, the points allocated by all the participants for each technology were added up, in relation to each criterion and to the overall attractiveness and feasibility. We asked participants to comment on the overall scores received by each technology regarding the overall attractiveness and feasibility evaluation. The participants were given a table to provide their opinions for any technology they wish to comment on. (The participants did not need to consider all the technologies in the table: they could just focus on a few technologies, i.e., those 3-4 technologies for which they particularly agreed or disagreed with the scores received in the previous Delphi round).

Finally, a third round took place when participants were asked to repeat the attractiveness and feasibility evaluation of each technology (as in Round 1 of the Delphi) in the light of the feedback received from the previous (second) round of the Delphi exercise. The criteria and procedure were exactly the same applied in the first round of the Delphi. They had the option to either change or confirm their evaluations in the first round. In addition, they were asked to repeat the process only in relation to the criteria of Overall Attractiveness and Overall Feasibility.

At the end of the third round of the Delphi exercise, the participants highlighted the technologies that result to be the most critical for UK SMEs operating in the digital health sector, i.e., the technologies that result to be, at the same time, the most attractive and feasible. These technologies, therefore, represent the main priorities for future investments.
In the next section of the report, we discuss the findings of the technology evaluation process.

After the third Delphi round concluded, two workshops were held with the participation of SME managers and the technology experts. The objective of the first workshop was to explore further the evolution of the critical technologies for Digital Health SMEs identified in the Delphi and their impact on future products and services and, more generally, the future growth of Digital Health SMEs. We also presented the aggregated results of the preliminary interviews we conducted with all the company managers, in relation to the main barriers and enablers of technology innovation in Digital Health SMEs. The objective of the second workshop was to explore the options available to SMEs for adopting/developing the new technologies (especially joint actions enabling SMEs to overcome the limitations - e.g., expertise, financial – of each individual firm).

4. Results

Critical technologies. The key output of the Delphi process was a set of critical technologies that were both *attractive* and *feasible* based on the original 26 identified from the literature. These represent the priorities for the future investments of the London based SMEs, especially those of the Digital Health London Accelerator. Precisely, four key technologies (i.e. the most attractive and feasible technologies for London–based digital health SMEs) from the first Delphi Round

1. Artificial intelligence
2. Big data Analytics
3. Internet of things
4. Smart devices

The results of the third round of the Delphi process confirmed the results of the first round, by actually increasing the overall scores and relative prominence of the four key technologies identified in the first phase. Four technologies clearly stood out in terms of both Attractiveness and Feasibility according to the experts and SME managers (see Figure 2). This is quite unusual (generally the technologies that are the most attractive are not the most feasible) but very encouraging.

At the end of the Delphi, the results were compared with the analysis of the citations of the 26 technologies of the Web of Science database. (i.e. the number of scientific articles mentioning the technologies in the title, abstract, or keywords). The Web of Science is an online subscription-based scientific citation indexing service providing a comprehensive citation search. It gives access to multiple databases that reference cross-disciplinary research, which allows for in-depth exploration of specialized sub-fields within an academic or scientific discipline. This comparison revealed that the four key technologies stemming from the Delphi exercise are not those receiving the highest levels of the attention in the scientific literature. This is a result of the different focus of the Delphi and Web of Science citation analysis: while the Delphi focused on UK digital health SMEs based in the London area, the Web of Science citation analysis covered any kind of institution and firm, at the global level (see Figure 3 and Figure 4).

Figure 2. Result of the third Delphi round

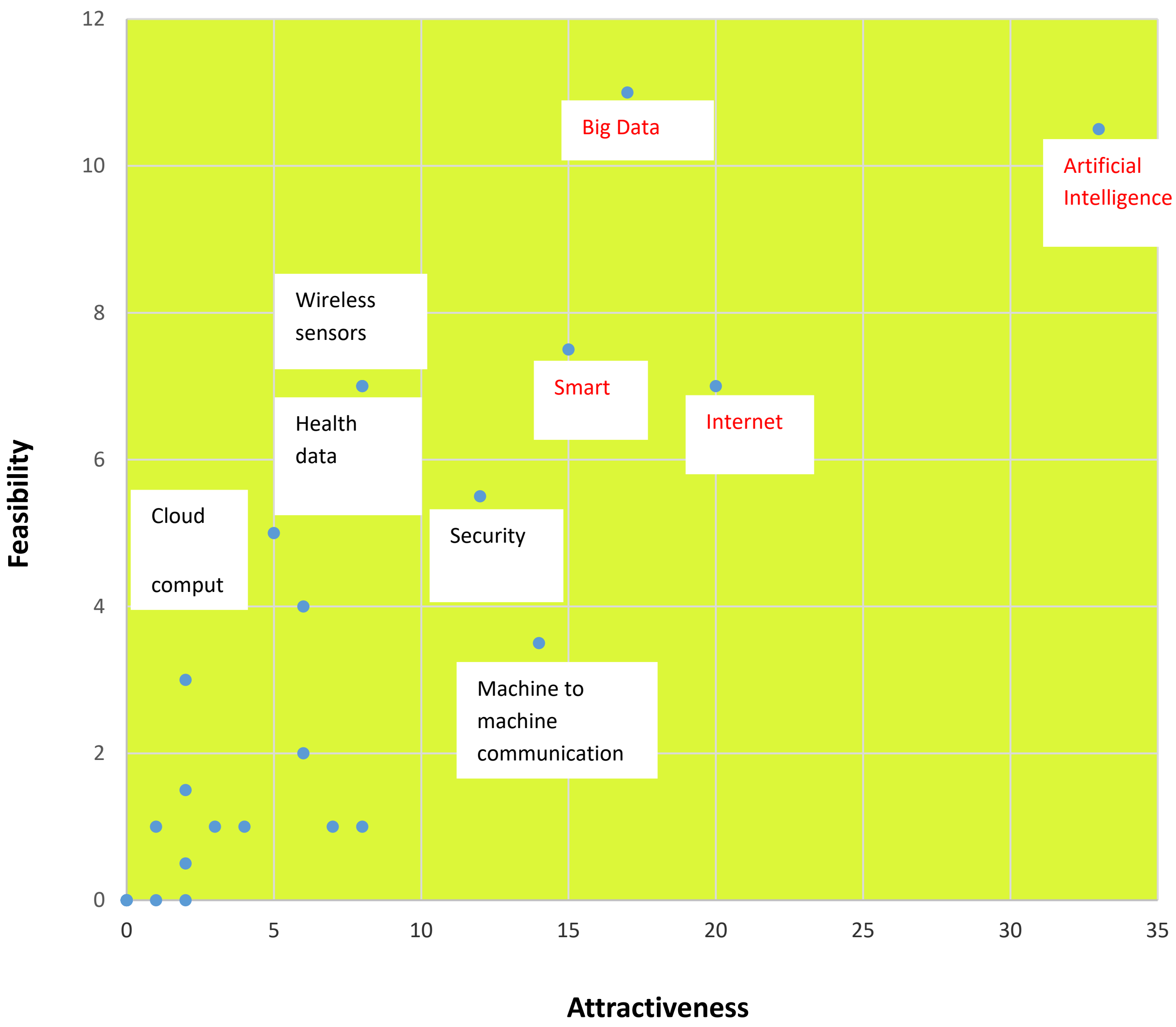
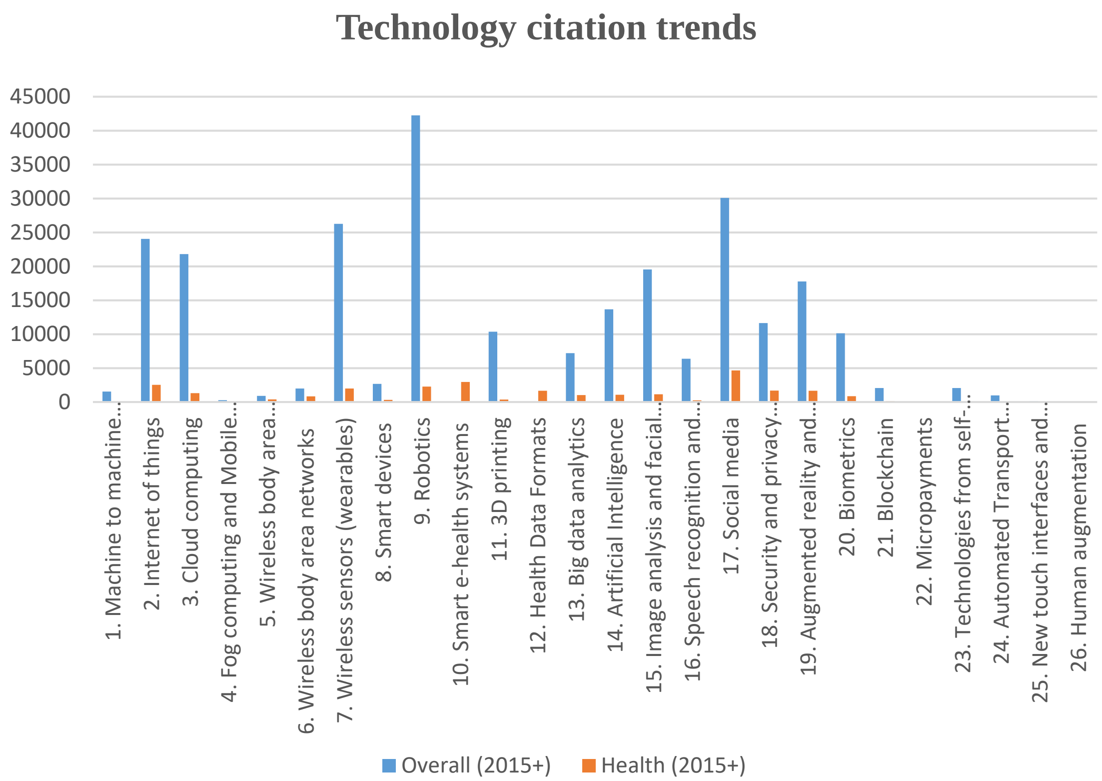
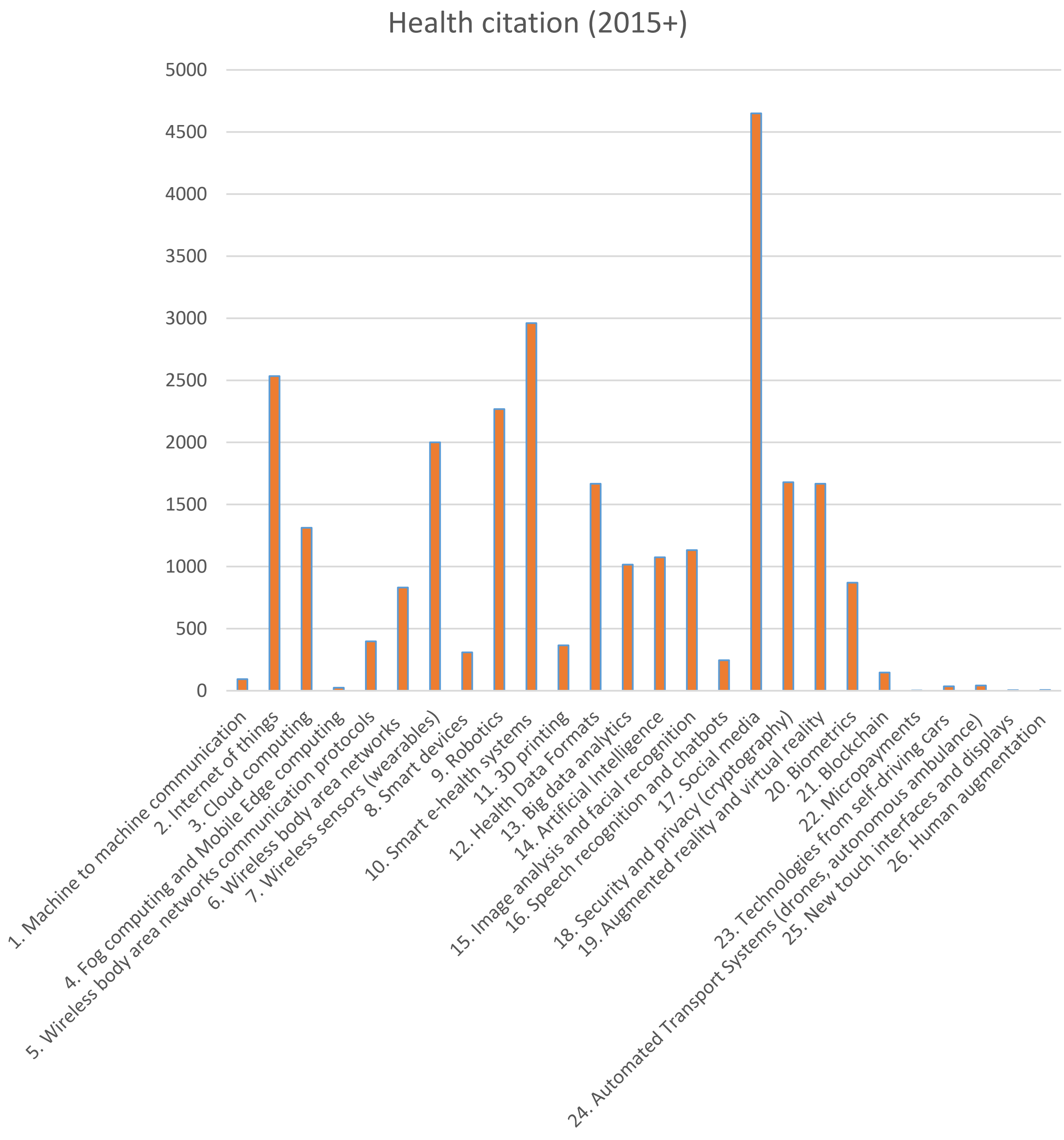


Figure 3. Overall (any industrial sector) technology citation and Health Sector technology citation (from January 2015 to April 2019)



Source: Web of Science

Figure 4. Technology citations specifically related to the Health Sector (from January 2015 to April 2019)



Source: Web of Science

Critical actions. After the end of the Delphi, the workshops that were held in late April led to the identification of a set of actions for fostering the development and transfer of the relevant technologies identified in the Delphi process (especially Artificial Intelligence and Big Data

Analytics) to the London based digital health SMEs. First of all, data access to NHS records is considered to be an essential enabler of new Artificial Intelligence based products and services, by helping SMEs to understand patients' needs and problems and the role of new digital technologies in addressing these problems. Digital Healthcare start-ups often experience difficulties in accessing data due to their limited resources and networking. The way information is retrieved and collected from patients should include (and actually emphasize) intuition, from both patients and GPs, and their tacit knowledge. This will bring about a big opportunity to develop health records that combine health data, and social care.

The second critical action regards collaboration with hospitals and medical centres. SMEs should team up with hospitals and clinical research team to enhance knowledge sharing, data access, funding, and build a vision for the future of digital healthcare. Such collaboration should involve as well universities, research centres, and stakeholders who can provide early feedback, accelerate knowledge transfer and information exchange.

Third, education is necessary since early stages (e.g., primary school) foster the development of a favourable environment, enhancing mutual understanding and nurturing a wide range of capabilities in both service providers and final users, such as problem-solving, idea generation, analytical skills, networking and relational skills. These capabilities in turn would be beneficial to enhance the adoption of digital technologies and services.

Fourth, it is necessary to define lead projects and products. SMEs need to focus on a selection of priorities in terms of products and services. Traditional NHS procurement practices often favour large corporations, by promoting large-scale projects (and procedures) that are too large for SMEs to bid for. By focusing on a few projects and products, SMEs can develop state-of the art skills that might ultimately enable them to partner with leading, large corporations.

Contextually, standard public procurement procedures so be revised so that SMEs can have an easier understanding and access.

Fifth, concerning funding, innovative approaches to fundraising were discussed during the workshop. Such approaches include crowdfunding, private venture capital and private equity. A relevant new trend in fund raising is Initial Coin Offering (ICO), which recently proved successful in enabling healthcare start-ups to raise money in a considerably short period of time (e.g. MedicalChain, Docademic). ICO involves the initial offering of a digital cryptographically secure piece of data (a digital token) created on a blockchain as part of a decentralised software protocol. An ICO is a popular way to raise money for a new project/start up by distributing a percentage of the initial currency supply to early supporters of the relevant project. Unlike conventional crowdfunding, however, tokens are usually tradable via online exchanges. This liquidity helps attract investors, and means that the overall ICO process has similarities with both conventional crowdfunding and an Initial Public Offering.

5. Discussion and conclusions

Whilst the concept and application of the technology foresight methodology of technology diffusion is not new, it has tended to be a corporate level activity with few studies or applications to SMEs. This paper has sought to examine the utility of the technology foresight model for the adoption of technologies in SMEs. Empirically the paper focuses on UK digital health SMEs. This provided some clear lessons on the potential benefits of the technology foresight approach for SMEs. First, managers of SMEs involved in digital health are knowledgeable of new technologies and ready to take part in this kind of project because of the perceived benefits of the technology foresight approach to technology adoption. In technology orientated sectors there already appears to be a culture of openness and learning amongst SME owner-managers. This contradicts the often portrayed view that SMEs tend to be technologically backward or laggards.

Second, intermediaries and cluster stakeholders (in this case the Digital health London Accelerator) can have a relevant role in supporting the recruitment of SMEs participating in foresight projects. Such intermediaries can play a role in enhancing trust in the researchers undertaking foresight projects and attract the interest of SME managers. It is unlikely that an SME alone has the resources to stimulate a foresight approach discussed in this paper, and as such an anchor organisation is needed to provide the catalyst for its organisation. Indeed, one of the significant differences between a technology foresight programme for SMEs and for large corporate organisations, is inter-firm knowledge and collaboration and interaction amongst entrepreneurs from different SMEs.

Third, foresight can have a concrete impact on the investment decisions of SMEs even in the short-run. One of the managers participating in the project has already communicated his intention to start an artificial intelligence project (artificial intelligence is one of the critical technologies identified in the Delphi) and potentially involve one of the technology experts met during the workshops. Another manager pointed out that it would be very interesting to replicate the technology foresight project in other digital health clusters and compare the results – especially in relation to the feasibility of the relevant technologies identified in the Delphi.

Overall, this paper has presented evidence to demonstrate how the technology foresight methodology can boost technology adoption and learning amongst SMEs. Although the paper has focused on the method, approach and immediate outcomes of SME involvement, the results show that technology foresight has the potential to be a significant vehicle for technology adoption in SMEs. Hence, the paper adds to the limited body of knowledge on how foresight can affect technology adoption in SMEs. The approach may also be set within the broader eco-system literature and provides a basis for further investigation of the possible synergies between technology foresight and eco-systems.

Limitations and future research

Although this paper identified an appropriate process for a technology foresight approach for SMEs, the analysis has some limitations. The recruitment of digital health SMEs was potentially challenging but the development of links with Digital Health UK proved very beneficial for all parties. The scale of the project limits its generalisability. Had been more time and resources for a larger technology foresight project, we could have been more selective in relation to the companies participating in the project, especially in relation to such dimensions as the stage of their life cycle, size, and capability to grow. Second, the analysis is time-constrained. A longitudinal approach would enable a more formative assessment of the impact of the project and the new technologies adopted in participating firms. Furthermore, we could increase the number of criteria (both attractiveness and feasibility) used to assess the future evolution and impact of the emerging digital health technologies, in relation to their specific likely applications (innovative products and services). Contextually, we could explore the use of public procurement for stimulating the design and provision of innovative products/services (based on emerging technologies) from digital health SMEs. Finally, the project under scrutiny was limited to one location and one sector. It is important that other studies are undertaken to test the resilience and adaptability of the methodology and robustness of our analysis.

The foresight project provided some clear indications and guidelines on how it can be scaled up. First of all, in order to improve the *reliability and comprehensiveness* of the results and outcomes, it would be helpful to: a) increase the number of SME managers and technology experts involved in the process; b) e*xpand the time horizon* of the analysis so that both the SME managers and experts can have more time for collecting and elaborating data; c) consider enterprises that are not already in an incubator or geographical cluster. Second, the project involved 15 SMEs from the Digital Health London Accelerator (DHLA). In order to scale up the project and enhance its results and outcomes, it would be helpful to run the foresight process and apply this innovative methodology in two or three different clusters of digital health SMEs elsewhere. This would allow a comparison of the results and to look for similarities and synergies between different territories. Third, it would be helpful to increase the number of criteria (both attractiveness and feasibility) used to assess the future evolution and impact of the emerging digital health technologies, in relation in particular to their likely applications (innovative products and services). In particular, we aim to explore the use of public procurement (i.e., public measures which attempt to pull through innovations and the diffusion of innovations) for stimulating the design and provision of innovative products/services (based on emerging technologies) from digital health SMEs. Finally, it would be useful to apply this foresight methodology to other sectors related to Digital Health, e.g., the digital game industry or the autonomous (self-driving) car sector. In this way, we can improve/expand the methodology itself and test/adapt it to different contexts, by pointing out potential technological synergies and opportunities for collaboration among the SMEs of different (but related) sectors.

References

BEIS (2018) Business productivity review – government call for evidence, Department for Business, Energy and Industrial Strategy, report. https://www.parliament.uk/business/committees/committees-a-z/commons-select/business-energy-industrial-strategy/inquiries/parliament-2017/small-business-inquiry-17-19/publications/

Georghiou, L., Harper, J.C., Keenan, M., Miles, I. and Popper, R. (Eds.). (2008). *The handbook of technology foresight: concepts and practice*. Edward Elgar Publishing.

Laveren, E., Blackburn, R., Ben-Hafaïedh, C., Díaz-García, C., & González-Moreno, Á. (2020). (Eds.) *Sustainable Entrepreneurship and Entrepreneurial Ecosystems*. Edward Elgar Publishing.

Martin, B. (1995) Foresight in science and technology. *Technology Analysis & Strategic Management* 7, no. 2: 139–68.

Miles, I. (2010). The development of technology foresight: A review. *Technological Forecasting and Social Change*, 77(9), 1448-1456.

Milliken, F.J. (1987). Three types of perceived uncertainty about the environment: state, effect, and response uncertainty, *Academy of Management Review,* 12:133–143.

Nesta (2017) The state of small business – Putting UK entrepreneurs on the map, ISBN 978-1-84875-161-3.

Nguyen, T. H., Newby M. and Macaulay M. J. (2015). Information technology adoption in small business: Confirmation of a proposed framework. *Journal of Small Business Management* 53 (2015): 207-227.

ONS (2017). Understanding firms in the bottom 10% of the labour productivity distribution in Great Britain: "the laggards".

Peltier, J.W, Zhao, Y. and Schibrowsky, J.A. (2012). Technology adoption by small businesses: An exploratory study of the interrelationships of owner and environmental factors, *International Small Business Journal* 30(4): 406-431.

Porter, M. 1990. *The competitive advantage of nations*. New York: Free Press.

Roveda C., Vecchiato R. (2008). Foresight and Innovation in the context of industrial clusters: the case of some Italian districts, *Technological Forecasting and Social Change* 75(7): 817-833.

Solomon, G. T., and Linton, J.D. Editorial (2016). Standing at the crossroad of knowledge: Technology, innovation, entrepreneurship and the small business management – Policy perspectives, *Technovation* 1-3.

Suarez F. and Lanzolla G. (2007). The Role of Environmental Dynamics in Building a First Mover Advantage Theory, Academy of Management Review 32 (2007) 377 392.

Vecchiato, R. (2012). Environmental uncertainty, foresight and strategic decision making: an integrated study. *Technological Forecasting and Social Change*, 79(3): 436-447.

Vecchiato, R. (2015). Creating value through foresight: First mover advantages and strategic agility. *Technological Forecasting and Social Change*, 101: 25 – 36.

Vecchiato, R. and Roveda C. (2014). Foresight for Public Procurement and Regional Innovation Policy: the case of Lombardy, *Research Policy*, 43: 438-450.

Wiener, M., Gattringer, R., and Strehl, F. (2020). Collaborative open foresight-A new approach for inspiring discontinuous and sustainability-oriented innovations. *Technological Forecasting and Social Change*, 155, 119370.